Briefing on Bay Bridge Bolts - May 29, 2013

THE SAN FRANCISCO-OAKLAND BAY BRIDGE SEISMIC SAFETY PROJECT

CALTRANS BAY AREA TOLL AUTHORITY CALIFORNIA TRANSPORTATION COMMISSION

Developments and Progress

- Bolt Testing Regime and Schedule is Set
  - Important tests will be completed in the coming weeks on status of all bolts
  - Go/No Go determination of Labor Day opening will be made based on results by July 10, 2013
  - Facts about Bolts and Bridge Safety will drive opening decision

Developments and Progress

- Retrofit Solution Well Underway
  - Fabricator is XKT Engineering, Inc.
  - Work will be done locally (Mare Island)
  - Press Access to Fabrication In Progress
  - Schedule of Retrofit Completion Being Finalized

Developments and Progress

- Labor Day Opening Is Still The Goal, But Test Results And Retrofit Schedule Will Determine
  - Three-Day Weekend Best for Final Work and Opening
  - Caltrans Has Done This Before (3 Closures; Most Recently Labor Day 2009)
  - Go/No Go Recommendation on July 10, 2013

Three Key Questions

1. What caused the E2 anchor bolts manufactured in 2008 to fail?

2. What retrofit strategy should be used to replace the 2008 anchor bolts?

3. What should be done about other bolts on the SAS?

1. What caused the E2 anchor bolts manufactured in 2008 to fail?

Metallurgical Report on 2008 Bolts, Dated May 7, 2013

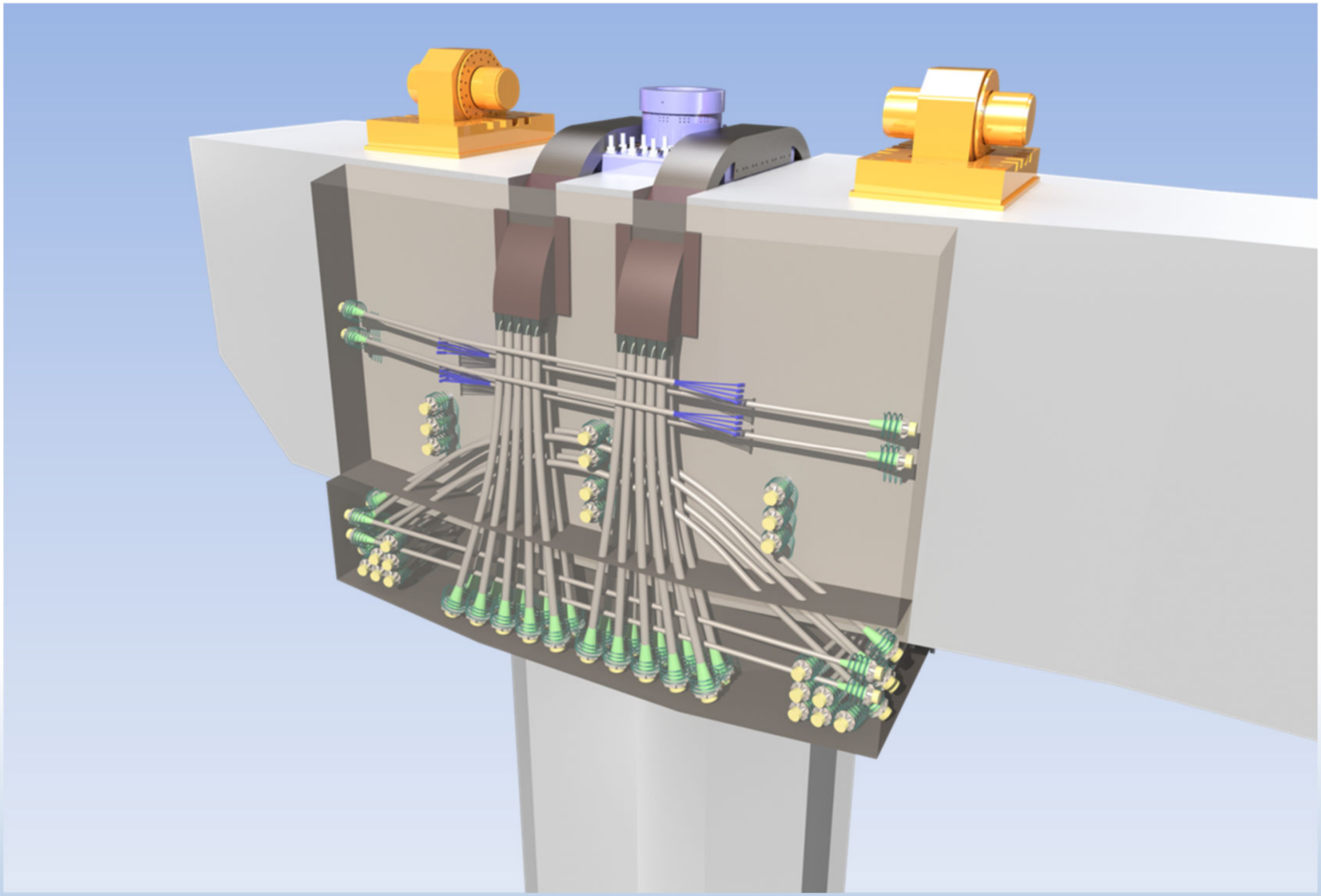
- The root cause of the failures is attributed to higher than normal susceptibility of the steel to hydrogen embrittlement.

- The metallurgical condition of the 2008 bolts was found to be less than ideal with large differences in hardness from center to edge, and high local hardness near the surface. The material also exhibited low toughness and marginal ductility.

- The combination of all of these factors caused the 2008 anchor rods to fail due to hydogen embrittlement.

2. What retrofit strategy should be used to replace the 2008 anchor bolts?

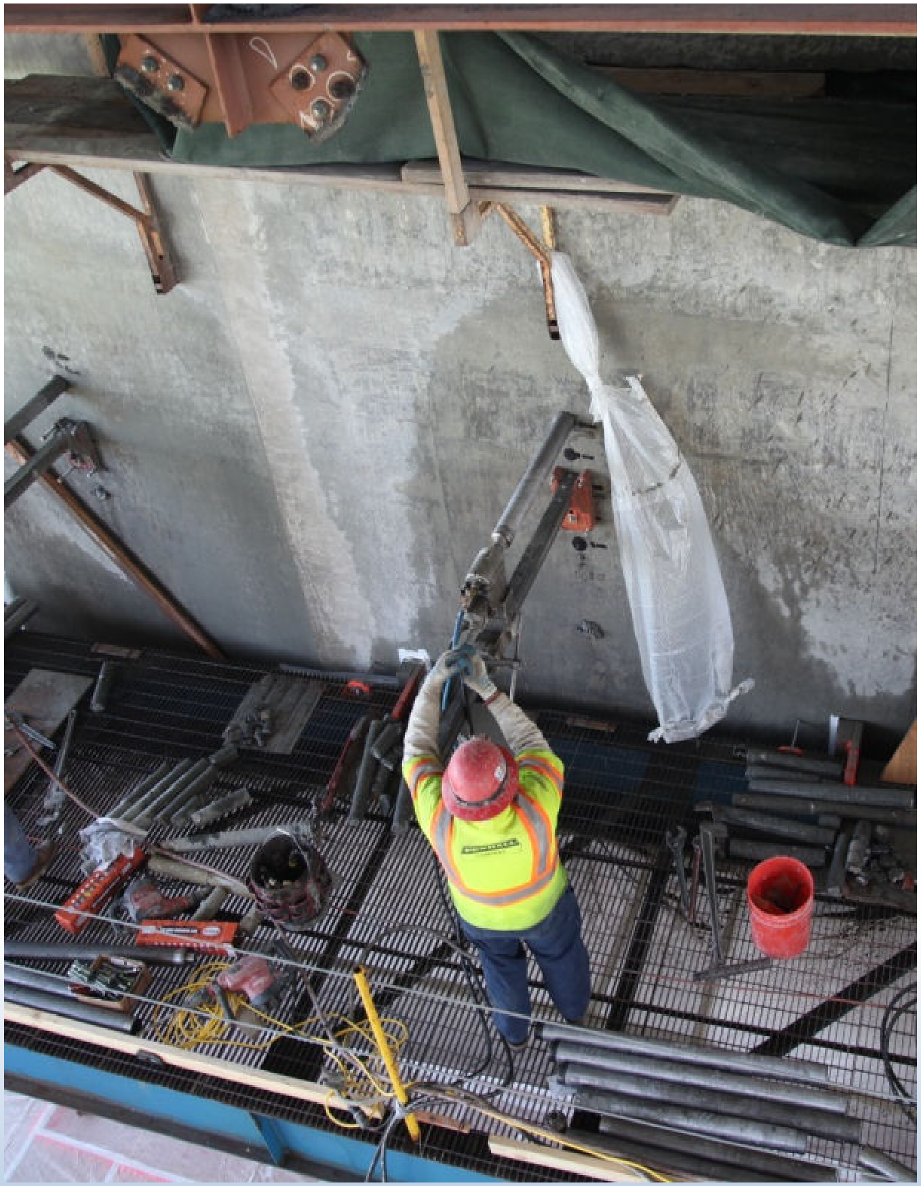
Steel Saddle Retrofit Option



Construction Progress on Retrofit

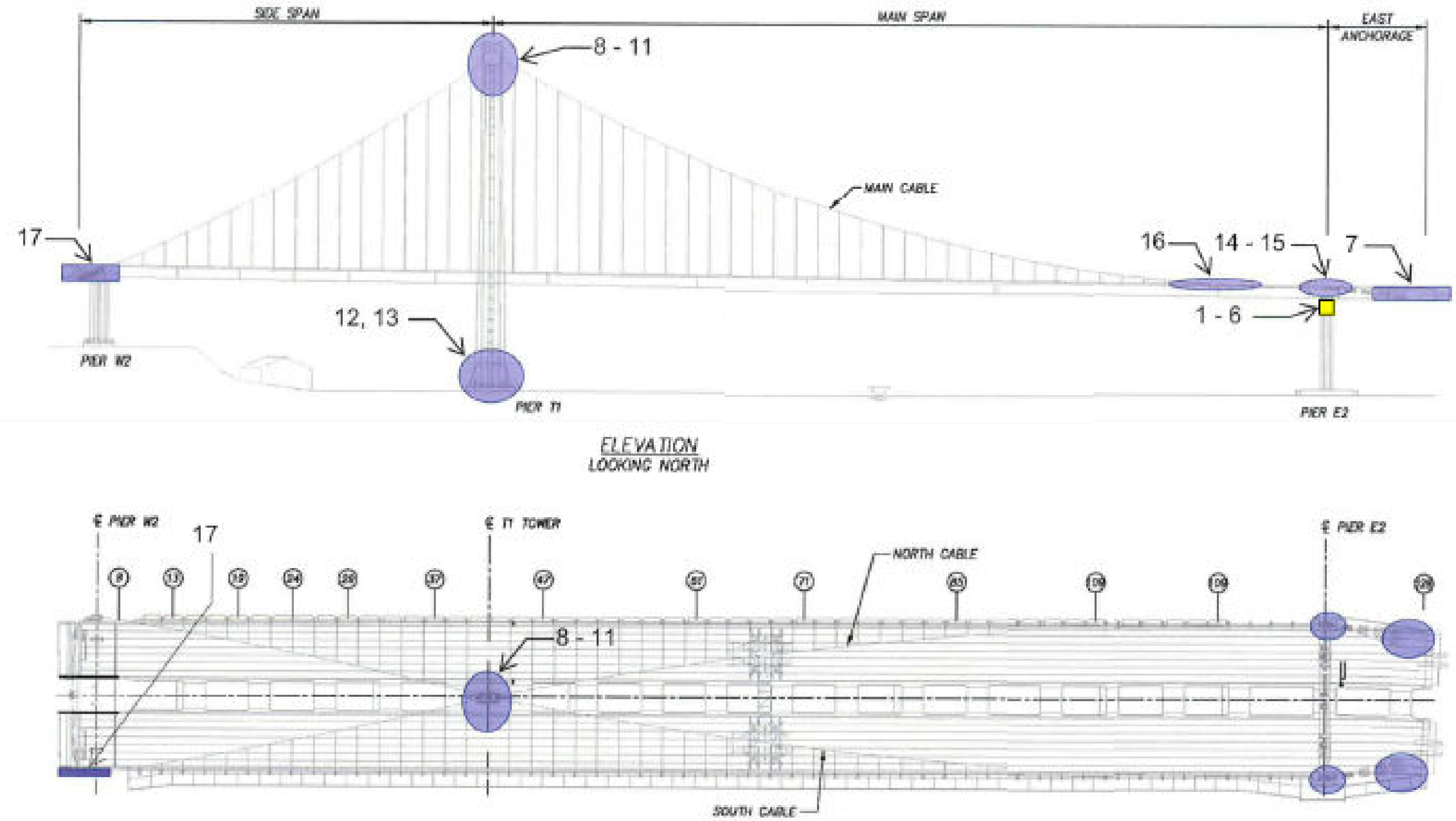
- **Design moving to shop drawing phase.**
- **Concrete removal and coring of E2 has begun.**
- **Material procurement ongoing.**

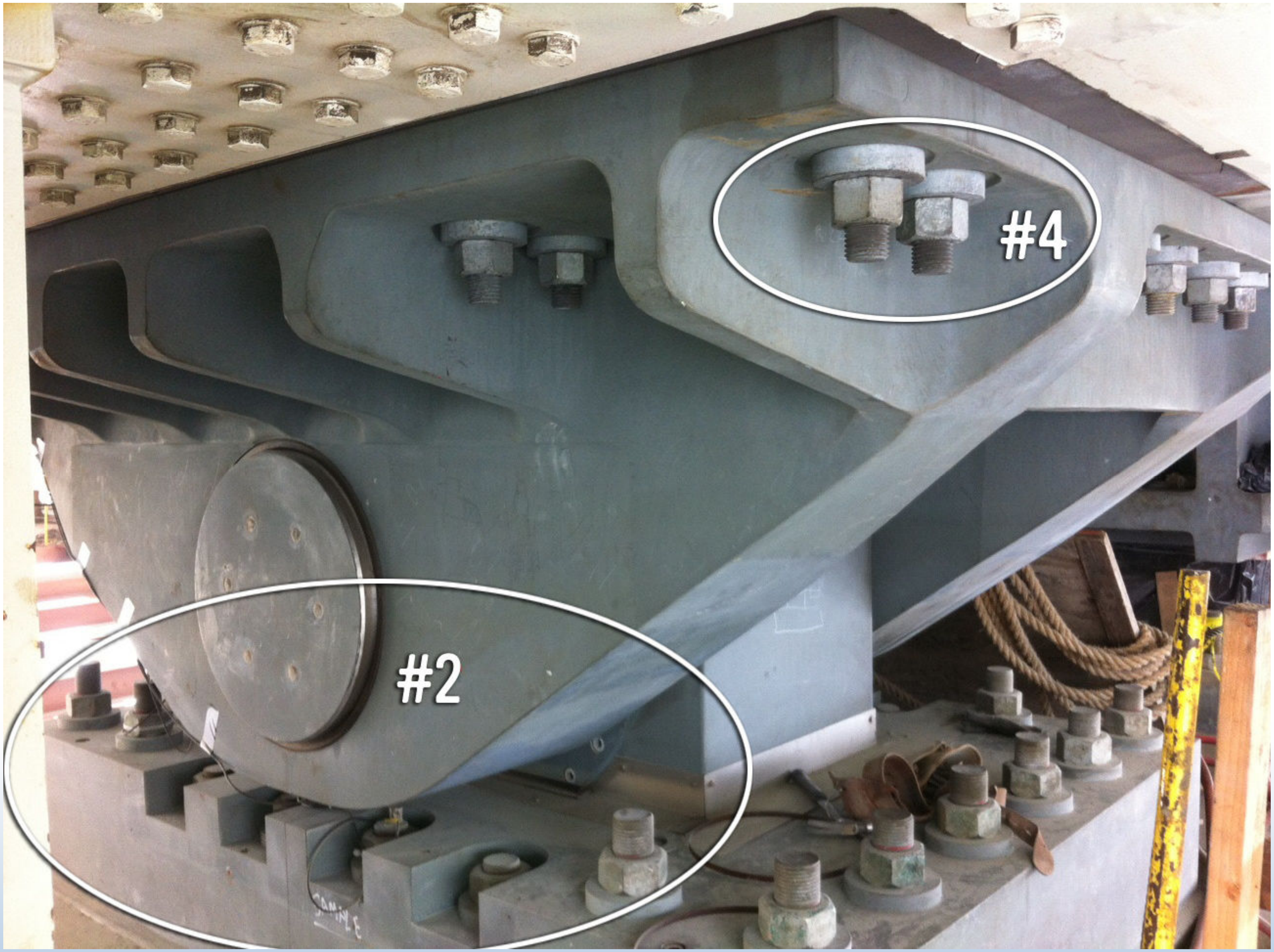
- Fabricator is XKT Engineering, Inc.
- Work will be done locally (Mare Island)
- Schedule of Retrofit Completion Being Finalized



3. What should be done about other bolts on SAS?

ASTM A354 Grade BD Rods Across SFOBB-SAS

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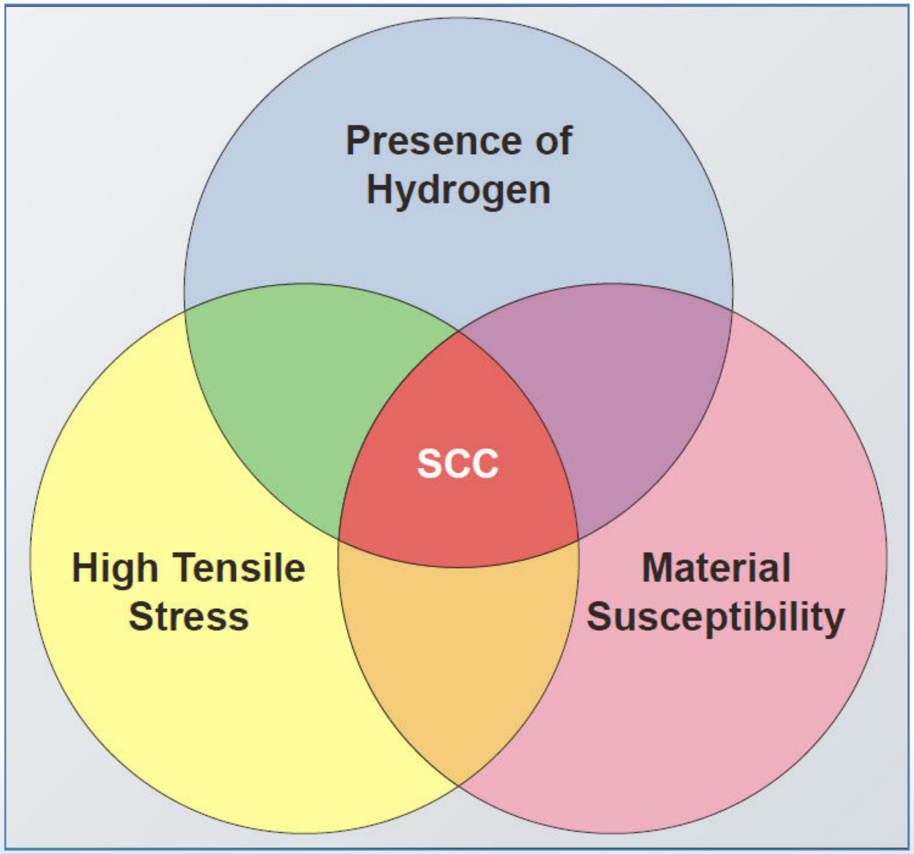
Stress Corrosion

- Based on regular inspection and ongoing testing, remaining bolts continue to perform as designed.
- Longer term concern is whether remaining bolts under high tension might be subject to stress corrosion cracking.
- Long term stress corrosion susceptibility is a function of the size and hardness of material, and level of tensioning.



A354 BD Galvanized Bolts

Location	Item No.	Description	Quantity Installed	Diameter (in)	Tension (fraction of Fu)	Average Hardness
E2	1	2008 Shear Keys Bolts	96	3	0.7	37
	2	2010 Shear Keys and Bearing Bolts	192	3	0.7	34
	3	Upper Shear Key OBG Connections	320	3	0.7	35
	4	Upper Bearing OBG Connections	224	2	0.7	35
	5	Bearing Assembly Bolts for Bushings	96	1	0.6	36
	6	Bearing Assembly Bolts for Retaining Rings	336	1	0.4	35
Anchorage	7	PWS Anchor Rods	274	3.5	0.4	35
Top of Tower	8	Saddle Tie Rods	25	4	0.4	35
	9	Saddle Segment Splices	108	3	0.5	37
	10	Saddle to Grillage Anchor Bolts	90	3	0.1	34
	11	Outrigger Boom	4	3	0.1	39
Bottom of Tower	12	Anchor Rods 3"	388	3	0.5	34
	13	Anchor Rods 4"	36	4	0.4	33
East Saddles	14	East Saddle Anchor Rods	32	2	0.1	37
	15	East Saddle Tie Rods	18	3	0.1	33
East Cable	16	Cable Bands	24	3	0.2	36
W2	17	Bikepath Anchor Rods	43	1	TBD	36
		Total	2306			

What to do with other bolts on SAS?

1. Replace before seismic safety opening
2. Replace after seismic safety opening
3. Modify by
    - Dehumidifying
    - Reducing tension
    - Additional Corrosion Protection
4. Acceptance, ongoing monitoring and maintenance

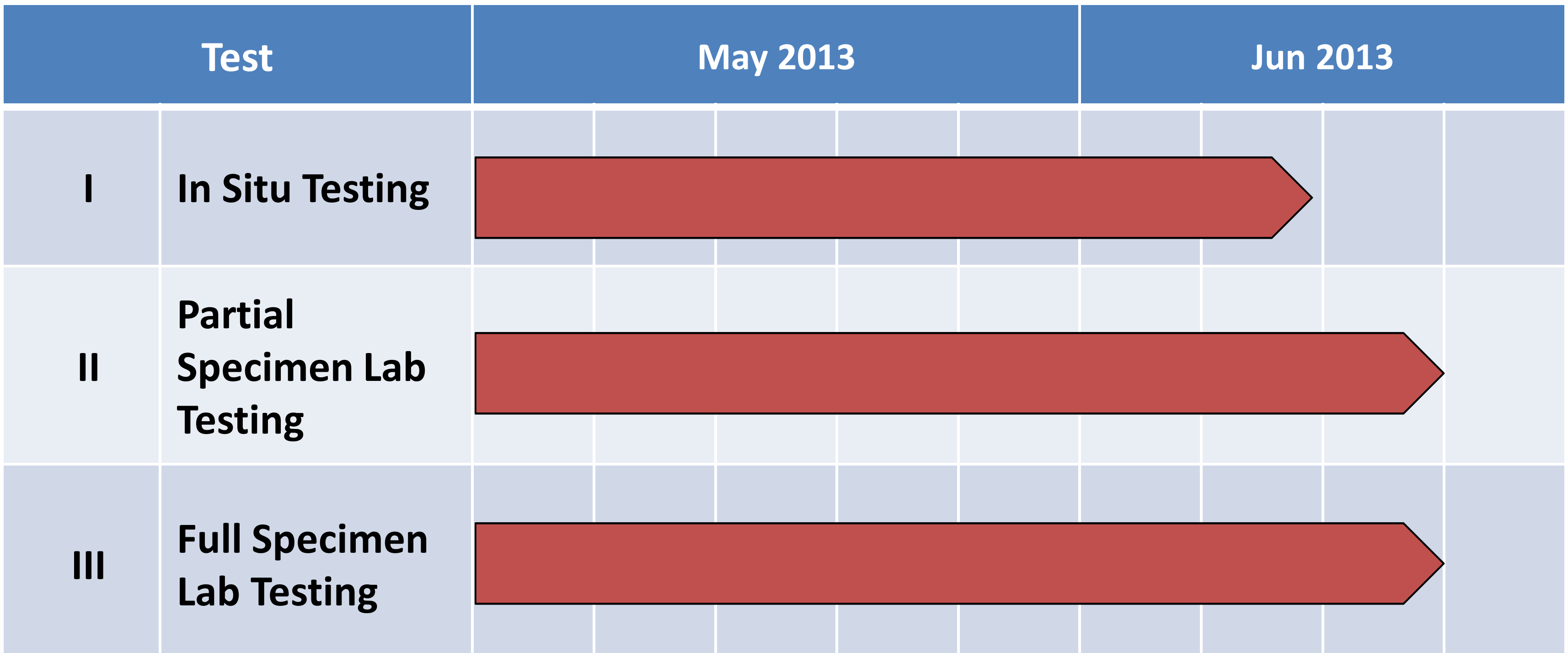
Purpose of Testing

- Collection of factual data on actual rods to guide decisions now and into the future
- All tests will provide data on the materials susceptibility to hardness and toughness
- Provides the capacity of the rods to continue carrying load in an extremely aggressive environment

Self Anchored Suspension Span A354 BD Test Plan

Location	Item No.	Description	I (In-Situ Test)	II (Partial Specimen Lab Test)	III (Full Specimen Lab Test)
E2	1	2008 Shear Keys Bolts	TBD	TBD	TBD
	2	2010 Shear Keys and Bearing Bolts	164	-	4
	3	Upper Shear Key OBG Connections	320	12	4
	4	Upper Bearing OBG Connections	224	7	2
	5	Bearing Assembly Bolts for Bushings	-	-	-
	6	Bearing Assembly Bolts for Retaining Rings	-	-	-
Anchorage	7	PWS Anchor Rods	270	43	1
Top of Tower	8	Saddle Tie Rods	25	2	1
	9	Saddle Segment Splices	20	2	-
	10	Saddle to Grillage Anchor Bolts	-	-	-
	11	Outrigger Boom	-	-	1
Bottom of Tower	12	Anchor Rods 3"	194	8	1
	13	Anchor Rods 4"	36	4	-
East Saddles	14	East Saddle Anchor Rods	16	2	1
	15	East Saddle Tie Rods	9	1	-
East Cable	16	Cable Bands	12		-
W2	17	Bikepath Anchor Rods	9	1	-

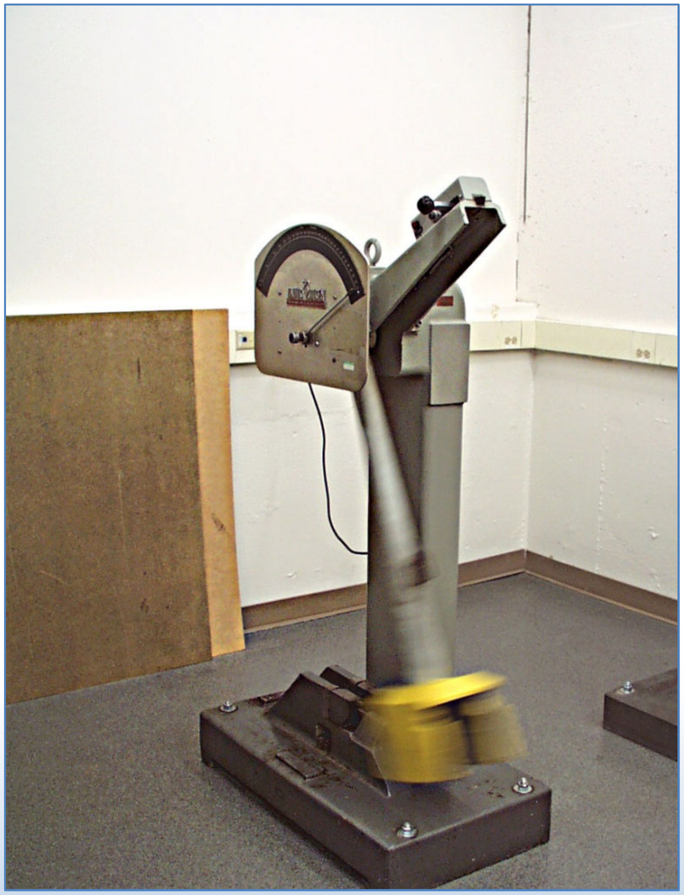
Schedule for Tests I, II, and III



- Ongoing in-situ and laboratory testing on other bolts will provide necessary information for bridge opening decision.

I. In-situ Testing (Hardness Tests)

II. Partial Specimen Lab Testing



III. Full Specimen Lab Testing

IV. Stress Corrosion (Townsend) Test

- The Townsend test is an accelerated test being prepared to determine the longer term susceptibility of the material to stress corrosion.

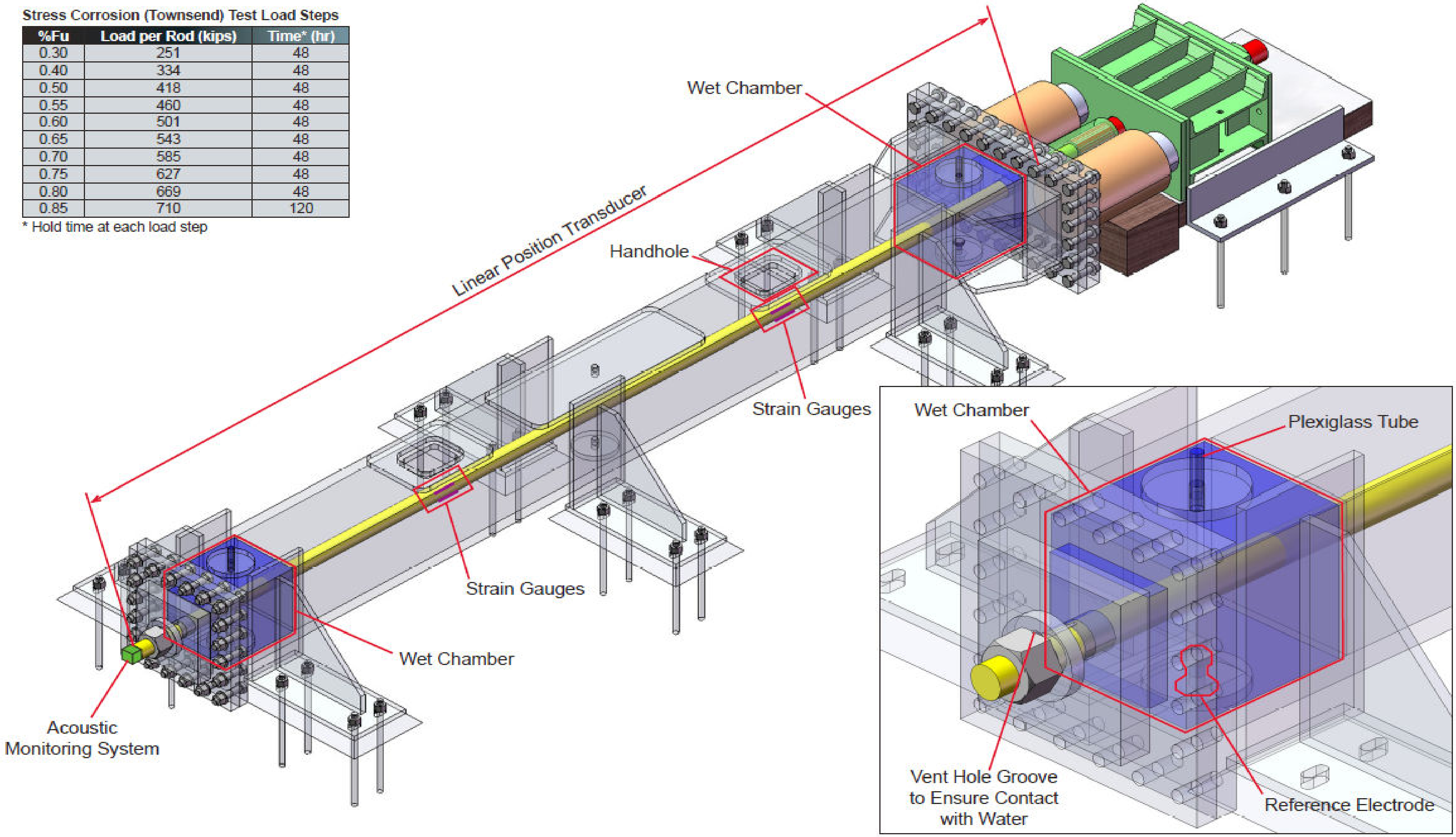
- Full sized bolts will be soaked in a controlled concentrated salt solution while tensioned progressively over a number of days until failure.

Test Set-up for Stress Corrosion (Townsend) Test

Stress Corrosion (Townsend) Test Load Steps

%Fu	Load per Rod (kips)	Time* (hr)
0.30	251	48
0.40	334	48
0.50	418	48
0.55	460	48
0.60	501	48
0.65	543	48
0.70	585	48
0.75	627	48
0.80	669	48
0.85	710	120

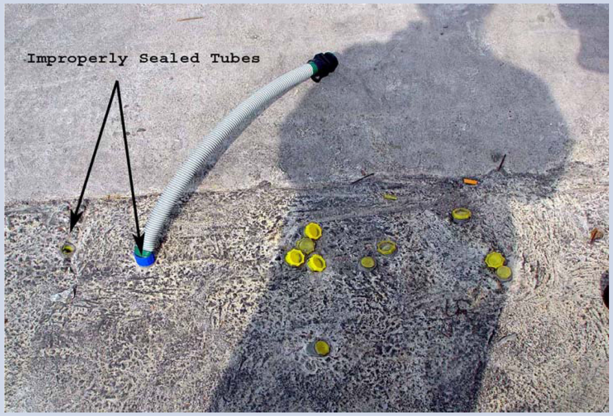
* Hold time at each load step



Construction Challenges

Challenge	
1. Electroslag Welding at Tower Base • Inspectors have found a number of imperfections in electroslag welds at the base of the tower. • Engineers are methodically mapping welds and determining which imperfections must be removed and replaced with quality weld material to ensure that all weld capacities exceed seismic demands for the 1,500 year design motions. • The process has been underway for about nine months, and is continuing.	

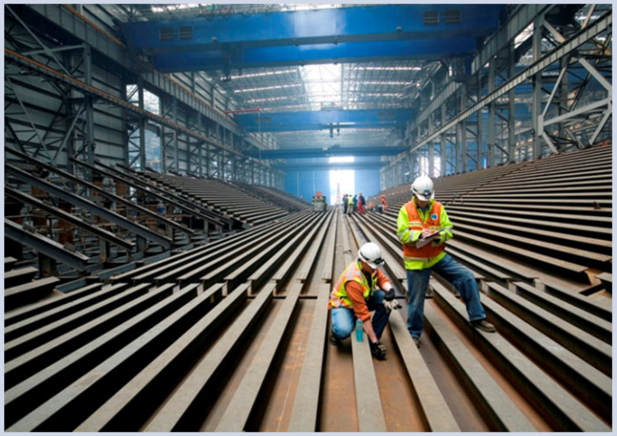
Construction Challenges

Challenge	
2. Skyway Tendon Corrosion • On the skyway portion of the bridge, concrete sections are clamped together with internal steel cables known as pre-stressing tendons. • Grouting of the pre-stressing was delayed, after inspectors learned that pumping grout in one tube could potentially get into another tube, clog it, and prevent a cable from being installed. • Engineers conducted inspections and discovered grout vents had been broken and not repaired. Rain water entered the vents and partially filled the pre-stressing ducts leading to some steel corrosion. Additional inspections and lab testing were done and it was concluded the steel was within tolerance for successful use.	 

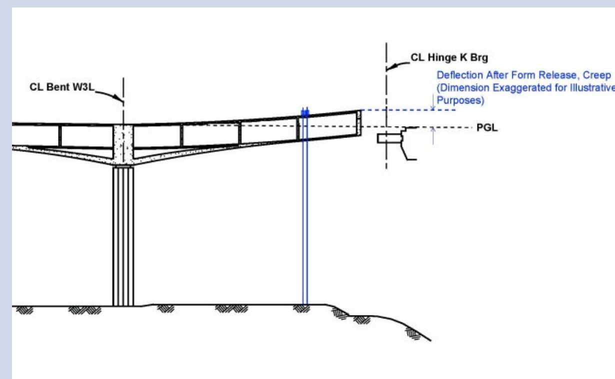
Construction Challenges

Challenge	
3. Bike Path Connection • While removing divider rails to make electrical and shimming modifications, Caltrans observed that some bolts securing the rails to the deck had been sheared, likely by thermal movement of the deck. • The bolted connection was restrained from thermal expansion and contraction by an oversized weld of architectural bolt caps to the base plate. • To resolve the problem, all divider panel bolts were removed, railings were modified with larger slotted bolt holes in the base plate and bolt caps were eliminated. • The railing work has been completed, it was estimated that 10% of over 2000 divider bolts may have had this problem.	 

Construction Challenges

Challenge	
4. Roadway Box Welding • Over the course of the project, weld quality has been raised and reported upon several times. • In 2008, inspectors found cracks in welds of deck plates in China. Supplemental testing was instituted and all cracks were repaired. • In 2008 to 2010 time period, field welding of deck segments in the Bay was not achieving required tolerances for planar alignment. Analyses were performed and repairs were made. • The challenges were reported to the Oversight Committee and in monthly reports. • The challenges were vetted by the Seismic Peer Review Panel and documented in a report in March 2011.	

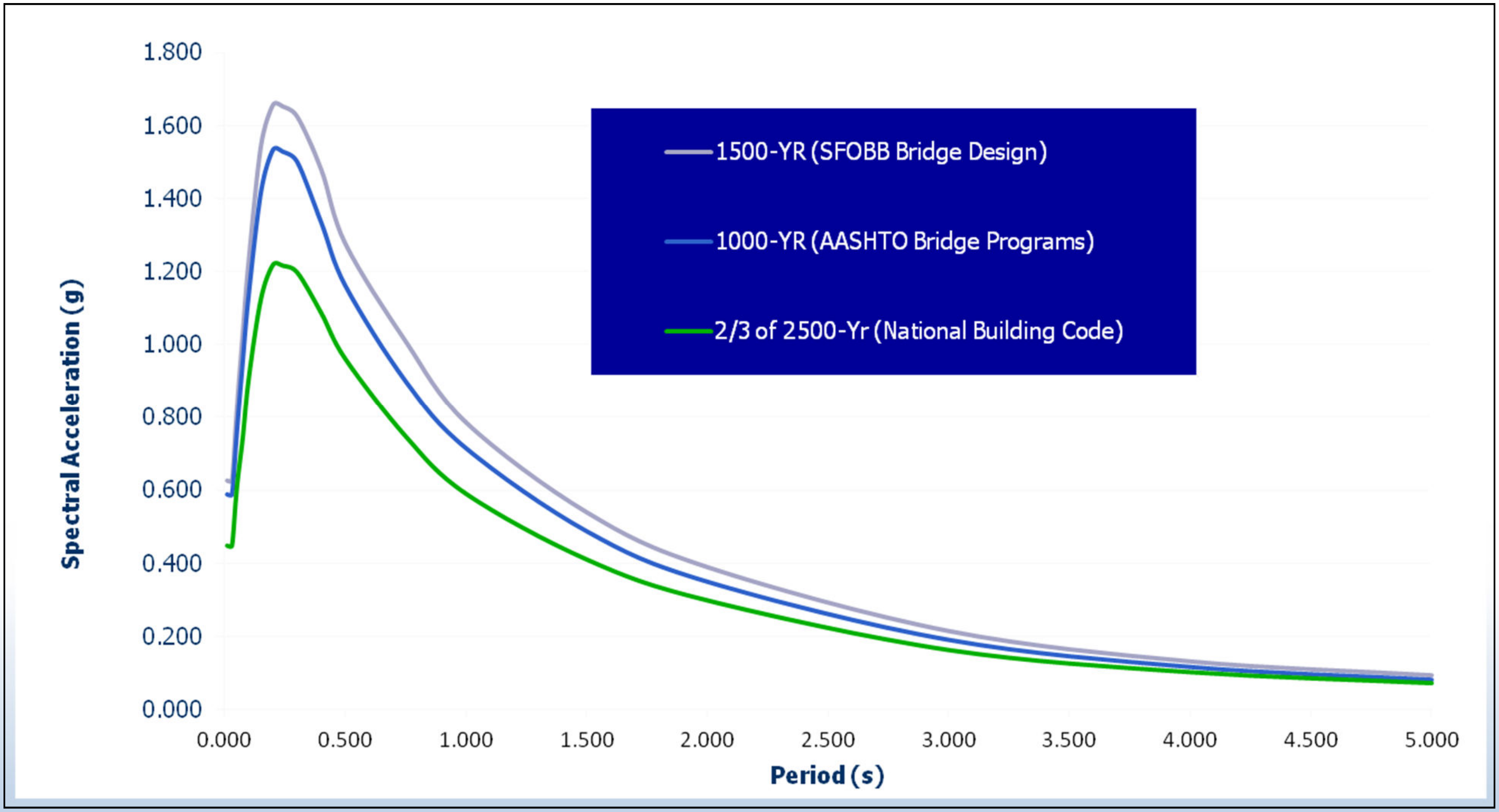
Construction Challenges

Challenge	
5. YBI/SAS Deck Alignment • The concrete section of the bridge between the Self-Anchored Suspension span and Yerba Buena Island was a few inches higher than the suspension bridge deck. The added elevation was the due to the pulling forces of the imbedded pre-stressing tendons. • Engineers carefully considered several options. • The steel ballast option was selected as best alternative.	 

Seismic Importance and Innovations

- "Important" Bridge - "Lifeline" design criteria
- Seismic Safety Peer Review not only for design criteria but also through design and construction
- Higher level of geotechnical testing
- Higher level of seismic, and other testing in laboratories and in the field
- Shear links in tower
- Seismic hinge pipe beam in deck joints
- SAS - YBI column design and test
- Maintenance and operation manual and tools

Comparison of Bay Bridge Seismic Criteria with Other Standards



Tower Shear Links

Hinge Pipe Beams

Investigative Structure

1. Toll Bridge Program Oversight Committee

CALTRANS BATA CTC

2. Seismic Peer Review Panel

3. FHWA

Items Expected at July 10 BATA Oversight Meeting

- Completion of written TBPOC investigative report, plus
- Firm schedule for E2 2008 bolt retrofit, plus
- Decision on other bolts on SAS, equals
- Decision on Seismic Safety Opening Date of Bay Bridge.